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Flax Production IN TEXAS

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Summary

Trial seedings of flax are recorded in Texas as early as 1900 but commercial flax growing started in 1938. Favorable seasons and war needs stimulated the acreage which reached a maximum of 349,000 in 1949 and a maximum value of $7,722,000 in 1948. The drouth years, 1951-56, greatly reduced the acreage but by 1960 it had increased to 80,000 acres.

All Texas flax is fall sown, the commercial acreage at present being concentrated in an eight-county area of South Texas ranging roughly from Corpus Christi northward to San Antonio. Cold tolerant winter-type varieties can be grown successfully as far north as Waco but little is grown now. Trials in North Central Texas at Denton prove that spring seeding in this area is possible but the crop has not become established commercially. Trial seedings on the High Plains have not been successful to date.

Flax is grown for the seed from which linseed oil, an important paint and varnish oil, is extracted. The meal is a valuable supplemental feed of approximately 35 percent protein and 3 percent oil. No fiber flax is grown in Texas. The flax straw is of little value under Texas conditions.

The flax crop, which is seeded in South Texas in late November or early December, fits well into rotations of cotton, Sudangrass, grain sorghum or vegetables where it sometimes is grown in a two-crop, 1-year rotation since flax is harvested in May. The "tighter" textured, fertile soils usually are used for flax. A few growers seed flax in rows but most of the crop is drilled on a firm seedbed free of weeds. Fertilizers are profitable only when there is adequate moisture or the crop is grown under irrigation. Weeds should be controlled by preplanting cultivation or by herbicidal sprays.

The northern spring-type varieties Deoro and B 5128 are the most popular varieties and are among the higher yielding strains in tests at Beeville and Kenedy. Smaller acreages of Linda, Crystal, Redwood and others are grown. The cold-tolerant varieties Turkey, Newturk and Caldwell were distributed to Texas growers but only a small acreage is grown now. The short season California varieties such as Punjab were grown in the Lower Rio Grande Valley for a time but are no longer grown.

The fall-sown flax crop usually is not damaged seriously by diseases. Rust, pasmo, wilt and seedling blights have caused some damage. During the dry seasons, 1955-57, curly top attacked flax in Texas causing moderate damage. Traces of aster yellows have been observed. These diseases are discussed briefly.

Flax Production in Texas

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THE EARLIEST RECORD of field planting of flax in Texas is that 50 acres were grown near Victoria in 1900. Flax was cut with a binder, but because there were no threshing facilities or market for the crop, it was left in the field.[1] Small plot tests of flax were made by the early dryland field stations of the U. S. Department of Agriculture at Dalhart, Channing and Amarillo, Texas about 1913 and a few farmers grew the crop successfully in that area.[2] Experimental trials of flax varieties were conducted at the U. S. San Antonio Field Station of the U. S. Department of Agriculture during 1918-34.[3] Trial seedings of flax were made by the Texas Agricultural Experiment Station at Troup, Nacogdoches, Angleton and Beeville in 1918, but no further tests were made until 1931, when spring-sown trials were started at Substation No. 6, Denton. Observational trials of fall-sown flax were conducted on farms and at substations in 1934 and 1935 and an expanded program of research in cooperation with the U. S. Department of Agriculture was started in 1936.

The first commercial acreages of flax were grown on farms in South Texas during the winter of 1937-38. The Kuhn Paint and Varnish Company, Houston, Texas, and the Archer-Daniels-Midland Company, Fredonia, Kansas, financed the purchase of 100 bushels of Bison flax for small field trials. The seed were distributed by the substations at Beeville, Angleton and Crystal City and trial seedings of 2 to 5 acres were made on farms in 14 counties from Houston to Brownsville. Good yields obtained in these tests encouraged further commercial seeding of flax.

The acreage expanded slowly for a few years because of damage by low temperatures, but after World War II the price of flaxseed was high and growing conditions favorable. Flax acreage expanded to a maximum of 329,000 in 1949. Severe fall and winter drouths during the 1950 and 1951 crop seasons and during 1955-57 caused a marked reduction in acreage but recently the acreage has expanded again. Table 1 gives the acreage, production and farm value of flax grown in Texas during 1938-60. Figure 1 shows the distribution of flax in 1949, the year of maximum acreage.

Uses and Markets

Flax is grown principally for the seed, from which oil is extracted. Flaxseed yields 32 to 44 percent oil (based on dry weight). This oil, called linseed oil, is used principally in the manufacture of paints and varnishes with smaller amounts being used in the manufacture of linoleum, oilcloth, printer's ink, patent and imitation leather products. The recent invasion of the market by rubber-base paints has reduced the demand for linseed oil in the paint industry.

After the seed are crushed for the oil, the meal, which still contains about 3 percent oil, is prepared for livestock feed by grinding or by making it into pellets. Linseed oil meal is a high protein supplement (35 to 40 percent), and is highly prized by livestock people because of its palatibility and slightly laxative effect. Ground whole flaxseed also may be used for feed but usually are too valuable. While the whole seed only have about two-thirds as much protein as the meal, the high oil content makes the seed one of the richest feeds in digestible nutrients.

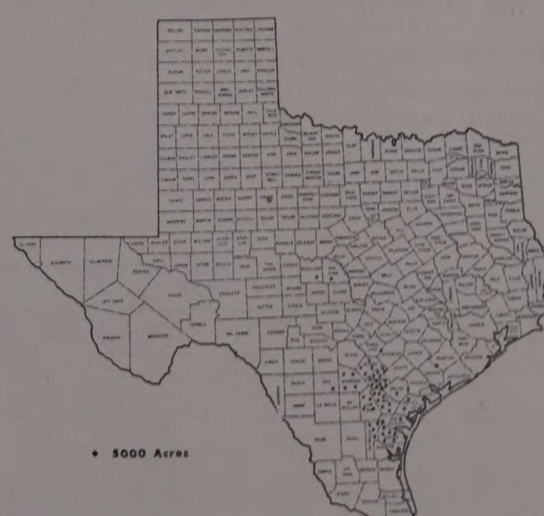

Figure 1. Distribution of flax in Texas, 1949.

[1] Taken from letters and unpublished records on file in the Department of Agronomy.

[2] U. S. Department of Agriculture Bulletin 283, 1913.

[3] Unpublished records on file in the U. S. Department of Agriculture offices, Beltsville, Maryland.

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TABLE 1. ACREAGE, PRODUCTION, YIELD PER ACRE, PRICE PER BUSHEL AND FARM VALUE OF FLAX, 1938-60

Year	Area harvested, acres	Annual production, bushels	Yield per acre, bushels	Price per bushel, dollars	Total farm value, dollars
1938	1,000	10,000	10.1	1.60	16,000
1939	18,000	207,000	11.5	1.65	341,550
1940	29,000	174,000	6.0	1.58	274,920
1941	15,000	105,000	7.0	1.62	170,100
1942	18,000	207,000	11.5	2.00	414,000
1943	34,000	272,000	8.0	2.61	709,920
1944	34,000	272,000	8.0	2.75	748,000
1945	63,000	504,000	8.0	2.75	1,386,000
1946	76,000	555,000	7.3	3.15	1,608,920
1947	91,000	864,000	9.5	5.70	5,057,325
1948	220,000	1,320,000	6.0	5.85	7,722,000
1949	329,000	1,974,000	6.5	3.44	6,791,000
1950	195,000	1,268,000	6.5	2.95	3,735,000
1951	22,000	75,000	3.4	4.00	300,000
1952	125,000	1,062,000	8.5	3.40	3,611,000
1953	124,000	868,000	7.0	3.40	2,951,000
1954	109,000	578,000	5.3	2.86	1,653,000
1955	32,000	96,000	3.0	2.77	266,000
1956	23,000	126,000	5.5	2.80	353,000
1957	17,000	119,000	7.0	2.61	329,000
1958	31,000	336,000	12.0	2.45	823,000
1959	38,000	357,000	10.5	2.90	1,035,000
1960	80,000				

Under Texas conditions flax straw has little value, although in some growing areas it is considered about the same in value as wheat straw. The straw should be plowed into the stubble to assist in maintaining organic matter of the soil. Under some conditions flax straw may have sufficient value to be gathered, baled and sold for industrial purposes. It can be used in the manufacture of upholstery tow, insulating materials, rugs, twine and paper. The manufacture of cigarette paper from flax straw is a new industry in some areas. The value of the straw is influenced by environmental conditions, diseases and by varieties to some extent.

Flax varieties grown in Texas are not suitable for fiber production used in the manufacture of linen. Fiber flax is grown under humid, high-rainfall conditions using varieties especially suited for fiber production.

Flaxseed grown in Texas may be processed at special flaxseed-oil mills, at cotton-oil mills, when certain adjustments are made, or the seed may be shipped to northern markets for processing. The oil content and iodine number, a measure of quality in oil, of Texas flaxseed compare favorably with those of the same varieties grown in other areas. These quality factors are influenced by variety and environment. The oil contents and iodine numbers of six flax varieties grown at Texas stations during the 6-year period, 1944-49, are shown in Table 2.

TABLE 2. OIL CONTENTS AND IODINE NUMBERS OF FLAX VARIETIES GROWN IN TEXAS, 1944-49

Variety	Percent oil		Iodine number	
	2-year average	6-year average	2-year average	6-year average
Rio	36.2	38.5	164	172
B 5128	35.8		172	
Viking	36.6		180	
Deoro	35.9		178	
Turkey	35.6	38.6	162	170
Newturk	36.6	39.1	164	173

Growing the Crop

Flax growing methods in Texas differ from those of the spring-sown flax growing areas of the North Central States. Practically all flax is fall sown in Texas, but spring seeding is possible in North Central Texas. Production now is centered in South Central Texas with the largest acreages in Karnes, Wilson, Atascosa and Live Oak counties. Flax is sown in late November or early December in this area and grows during the cool season of the year, maturing in late April or May. When moisture conditions are unfavorable, seeding in January sometimes is necessary but lower yields may be expected from late seedings.

Flax may be grown in a rotation of cotton, sorghum and flax or in a two-crop, 1-year rotation of fall-sown flax and a summer legume. It is better suited than most other crops to growing on land which has spots deficient in available iron, locally called "hot spots." Growing flax in South Texas requires no extra farm equipment and aids in the distribution of labor because it is grown during the winter.

Choice of Land

Flax may be grown on nearly any type of fertile land ranging from sandy loam to heavy "blackland." In South Texas it usually is grown on the "tighter" soils and less often on sandy soils. Flax does not compete well with weeds; therefore it should not be sown on soils heavily infested with weeds. Since Texas flax grows during the winter, the weed problem is less troublesome than in many other areas.

Seedbeds

Flaxseed are small and therefore should be sown on a firm seedbed at a shallow depth. When moisture conditions are good, the seed need not be covered more than one-half to three-quarters of an inch. Should the surface soil be dry, seed may be sown as deep as 2 inches in light-textured soil, if moisture is present. Weeds should be killed before flax is seeded if at all possible.

Seeding Methods

Flax always should be seeded with a grain drill, never broadcast and plowed in as is sometimes done in seeding oat pastures in South Texas. Using a cultipacker before seeding or press wheels on the drill may be advantageous if the soil is not firm or is light textured. Normally the 7 or 8-inch drill spacing is used, but where weeds are troublesome, some farmers prefer to

Figure 2. Flax seeded in wide-spaced rows alternating with rows of sweetclover at Beeville, 1956.

Figure 3. A commercial field of flax seeded in wide-spaced rows near Kingsville, 1956.

seed flax in wide-spaced rows. Often these wide-spaced seedings are 28 to 36 inches apart, but the seeded area is either a double row or a banded area. This 6-inch band of plants is created by a spreading device at the base of the planter shoe. Other growers may seed sweetclover or alfalfa between the flax rows for soil improvement and a summer forage crop. Flax seeded in wide-spaced rows is shown in Figures 2 and 3. Wide-spaced rows permit cultivation to kill weeds and may better utilize the limited moisture in dry seasons. The flax plants branch so that they finally utilize most of the space. Average yields have not been as high as regular drill spacings but under some conditions may be more satisfactory. Flax yields in rate and spacing trials at Beeville, 1950-56, are given in Table 3.

Rate of Seeding

When seeded with a grain drill, flax usually is seeded at 25 to 30 pounds per acre, with the lower rate used in the drier areas. The seeding rate has not greatly influenced yields at Beeville, Table 3. The seeding rate in wide-spaced rows often is reduced to 16 pounds per acre. Planting seed always should be cleaned, treated and the germination percentage should be determined. Several flax diseases may be transmitted through infected seed or plant parts. Seedling diseases may be reduced materially by proper treatment with an approved mercurical fungicide such as Ceresan or Panogen.

Time of Seeding

Since the rainfall in the main flax-growing area is erratic, it may not be possible always to seed at the optimum date. When moisture conditions permit, seeding between November 15 and December 10 is the most satisfactory period. Results of date of seeding tests at Kenedy, 1948-53, are given in Table 4. December 23 and January 10 seedings gave yields from 1.5 to 2.0 bushels less than those of November 15. February 5 seedings produced much lower yields. The November seedings of varieties in two seasons at Beeville, Table 5, produced an average yield of 17.4 bushels for the November seedings and 11.3 bushels for the December seedings. Late January or early February seedings are less desirable because the crop matures in hot weather and weeds become more serious.

Variety-date of seeding trials of spring-sown flax were conducted at Denton in North Central Texas during 1931-44. The average yield for all varieties sown March 10 to 17 was 12.7 bushels; for flax sown March 18 to 26, 11.1 bushels; and for flax sown March 28 to April 13, 5.3 bushels. Although flax has not been grown commercially in the North Texas area, these results show that it can be grown. The average date of the last killing frost at Denton is March 25, so flax sown to emerge before this date may be subject to injury by low temperatures. However, April seeding is unsatisfactory because the crop matures in the high-temperature months.

A few trial seedings of flax have been made at the U. S. Southwestern Great Plains Field Station at Bushland (near Amarillo) in recent years,

TABLE 3. YIELDS OF FLAX SOWN IN RATE AND SPACING TRIALS, BEEVILLE, 1950-56

Seeding rate per acre	Yield of grain, bushels per acre	
	12-inch rows	36-inch rows
16 pounds	6.5	6.5
24 pounds	6.9	6.5
32 pounds	7.5	6.9
40 pounds	6.9	6.6
Average	7.0	6.6
Flax interplanted with legumes, 1953-54		
12-inch drills		7.9
36-inch rows		6.2
8-inch drills (2 drilled, 2 skipped)		6.0
24-inch rows, Madrid clover seeded		5.4
36-inch rows, Madrid seeded between flax rows		5.7
36-inch rows, alfalfa seeded between flax rows		4.8

TABLE 4. YIELDS OF FLAX SOWN ON FIVE DATES DURING 1948-53, KENEDY[1]

Crop season	Yield of grain, bushels per acre				
	Date seeded				
	November 15	December 10	December 23	January 10	February 5
1947-48		9.7	5.3	7.1	3.3
1948-49	9.7		13.0		
1949-50		10.1	7.5	9.4	
1951-52	8.4	9.5			
1952-53	12.5	12.3		9.3	5.6
Average	10.2	10.4	8.6	8.6	5.0

[1]A. C. Dillman, mimeographed report of "Flax Experiments at Kenedy, Texas, 1947-53."

but all have been failures. High winds and dry surface soil, which often occur in this area, are unfavorable for germination of flax.

Fertilizers

Flax will respond with increased yields to fertilizer applications provided there is satisfactory moisture. Since moisture often is a limiting factor in the Texas flax-growing area, no response may be obtained in some seasons. Results of fertilizer trials at Kenedy are given in Table 6. Flax responded with increased yields to fertilizer applications in 1949 but no response to fertilizer was obtained in 1953.

These data show that fertilizer applications may be profitable some years but not in others. Where flax follows fertilized cotton or vegetables, additional fertilizers may not be necessary.

Weed Control

Flax does not compete well with weeds; therefore any cultural practice which reduces the weed population or potential population on the land to be seeded to flax is advantageous. These practices include proper selection of land, cultivation to kill weeds prior to seeding, rotation with clean-cultivated crops and seeding when moisture conditions are favorable so that flax will emerge promptly.

Fortunately fall-sown flax only has to compete with winter annual weeds such as evening primrose, wild lettuce, sow thistle and pigweeds. When harvest is delayed or maturity is late, the spring-emerging weeds such as lambsquarter, sunflowers, Johnsongrass and others may give trouble.

Several herbicides may be used to control weeds in flax where the value of the crop justifies this expenditure. The cost will vary with location, but usually ranges from $2.00 per acre upward. Flax is fairly resistant to 2,4-D (2-4-dichlorophenoxyacetic acid) or MCP (2-methyl-4-chlorophenoxyacetic acid) and although some distortion of the stems may occur, the plants usually grow out of it. The amine or sodium salts should be used and the spray should be applied when the plants are 2 to 4 inches tall, never after the plants are more than 8 inches tall. Three or 4 ounces (acid equivalent) per acre are needed for the control of broad-leaved weeds and may be applied by ground rigs in 15 gallons of water per acre or 5 gallons per acre by airplane. Sprays also may be used near maturity to kill many broad-leaved weeds and permit direct combining but often this is too expensive under Texas conditions. Several other herbicides may be used on flax, including some that control annual grasses, but since commercial spray products change rapidly as new ones become available, the grower should consult his county agricultural agent about his specific problem.

TABLE 5. YIELD OF FLAX VARIETIES FROM NOVEMBER AND DECEMBER SEEDINGS AT BEEVILLE, 1958-59

Variety	Yield of grain, bushels per acre					
	November seeding			December seeding		
	1958	1959	Average	1958	1959	Average
Deoro	14.2	21.6	17.8	7.2	13.5	10.4
Viking	11.6	21.7	16.7	10.0	10.1	10.1
Linda	13.0	18.9	16.0	12.5	10.7	11.6
Redwood	16.6	23.5	20.1	10.5	9.0	9.8
Bolley	12.5	16.2	14.4	10.2	10.9	10.6
B 5128	17.3	18.7	18.0	11.3	15.5	13.4
Caldwell	16.2	20.5	18.4	12.2	13.9	13.1
Average	14.5	20.2	17.4	10.6	11.9	11.3

Injury by Low Temperatures

Since flax is grown during the winter, it is subject to injury by low temperatures throughout much of the growing period. This may occur as winterkilling, frost damage to young seedlings or damage by late frosts after the plants are blooming. Varieties differ markedly in reaction to cold. The Punjab strains are very susceptible to cold and their early maturity further increases the chance of such damage. The spring-type varieties from the Great Plains also differ. Royal and Linda are very susceptible to cold. whereas Deoro, B 5128 and Rio have repeatedly shown considerable cold tolerance in Texas tests. The true winter-type varieties Newturk and Caldwell are much more cold tolerant than spring types, especially if they become well established

TABLE 6. YIELDS OF FERTILIZED AND NONFERTILIZED FLAX, KENEDY, 1949 AND 1953

Year	Treatment	Yield of grain, bushels per acre
1949	No fertilizer	10.1
	150 pounds 16-20-0	15.6
	300 pounds 16-20-0	16.3
1953	No fertilizer	11.1
	100 pounds ammonium sulphate	10.7
	200 pounds ammonium sulphate	9.8
	200 pounds 6-12-6	11.4
	200 pounds 16-20-0	11.7

TABLE 7. SURVIVAL OF FLAX VARIETIES AT TEXAS STATIONS, 1940-49

Variety	Percent survival, station and crop year								
	Angleton	Temple	College Station				Denton	Kenedy	
	1940	1942	1943	1944	1947	1948	1944	1948	1949
Bison	10	40	5						
Rio	25	56	5	40	14	8	0	95	45
Punjab	1	1	0	0	0	0	0	2	6
Bolley's Golden	40					8		92	36
Deoro	15					5			44
B 5128						24		92	38
Turkey	90	95	60	100	71	95	20	98	98

before the low temperatures occur. They have repeatedly survived in nursery tests in Texas when the temperatures dropped below 20° F. and on one occasion, with snow cover, survived a temperature of 3° F. at College Station. By contrast, the spring types may be damaged at temperatures below 25° F. and, if blooming has started, flowers may be killed near the frost level of 32° F. The relative hardiness of several varieties during 1940-49 at Texas stations is shown in Table 7.

The most extensive winter injury to the commercial crop occurred in 1940 when the fall-sown crop was destroyed as far south as Sinton (San Patricio county) and Victoria (Victoria county). Temperatures dropped to 16° F. at Beeville and 5° F. at Temple. A considerable acreage was reseeded in January that season. The most severe temperatures in history occurred in the flax area in 1949 with a record 5° F. at Kenedy (Karnes county), but snow protected the crop and most of it survived. Severe spring freezes killed an estimated 2,000 acres in McCulloch and San Saba counties in 1948 and a March freeze in 1952 damaged fields in Karnes county. The degree of damage, location, season and low temperatures when the commercial flax crop was damaged in Texas are shown in Table 8. Relatively little damage from low temperatures has occurred since 1949.

Other Production Hazards

Seasonal rainfall is extremely important in fall-sown flax production in Texas. Average yields for Texas are related closely to rainfall from October to May. Severe drouths in 1940, 1941, 1951 and during 1954-56 seriously hampered seeding and reduced acreage and yields. Excessively wet weather and storms damaged the crop along the coast in 1941 and in the Lower Rio Grande Valley in 1941-42. Seasonal rainfall at Beeville and average flax yields in Texas during 1950-59 are given in Table 9.

Harvesting

All flax is harvested with the combine harvester-thresher either by direct combining of the standing crop or by windrowing and later combining from the windrow with a pickup attachment. When weeds develop before maturity, the crop is uneven in ripening or excessive rains keep the stems succulent, it may be desirable to windrow the crop to allow it to dry. Windrowing should be done when about 90 percent of the bolls are brown and mature.

The flax seedcoat is injured easily in threshing. The rub-bar type cylinders and concaves usually damage the seed less than teeth-type concaves. Only sufficient speed to remove the seed should be used and excessive speeds should be avoided. Cracked or injured seed are more difficult to store and the germination may be seriously reduced by these injuries. Figure 4 shows a field of flax being combined near Karnes City.

Seed Cleaning and Storage

When flax was first grown in Texas, there were few facilities on farms or in commercial channels for proper care of the seed, so new planting seed were imported from Northern States each season. Research on storage of flax and other grains has provided information on safe storage methods of grain on farms or in commercial storage houses in South Texas. Because

TABLE 8. DAMAGE TO FLAX BY LOW TEMPERATURES IN TEXAS

Year	Month	Station	Temperature	Injury
1937	January	College Station	26° F.	Punjab killed, Bison uninjured
1940	January	College Station	8° F.	All varieties killed
1940	January	Angleton	8° F.	Differential killing
1942	January	College Station	19° F.	Frost damage, no reduction in stand
1942	January	Temple	15° F.	Differential killing
1943	January	College Station	13° F.	All varieties killed
1943	January	Denton	4° F.	Turkey types killed
1944	December	College Station	20° F.	Killed Punjab, others survived
1944	December	Temple	17° F.	All varieties killed
1947	January	College Station	16° F.	Differential killing
1948	January and March	College Station	20° F.	Differential killing
1948	January	Temple	20° F.	Differential killing
1948	January	Kenedy	23° F.	Differential killing
1955	March	College Station	22° F.	Damage to bloom stage, no stands reduced

Figure 4. Combining flax near Karnes City, 1958.

of the high humidity, high temperatures and the abundance of insects which are active throughout the year, special care is necessary to protect grain in storage. Seed must be stored at low moisture content with complete insect control. Freshly harvested seed of 14 to 18 percent moisture may be dried at 175° F. without injuring the germination, but seed with lower moisture content or planting seed should be dried at temperatures below 150° F. Flaxseed may be stored for many months without serious germination loss provided they are inspected frequently and proper storage conditions are maintained. Details on storing flaxseed may be obtained in TAES Miscellaneous Publication 172, "Storing Flaxseed in Farm-type Bins in South Texas."

Varieties

The three types of flax that can be grown in Texas are (1) the early-maturing, short-stature Indian flax varieties such as Punjab and Imperial which make up most of the California acreage of fall-sown flax; (2) the spring-type flax varieties from the northern Great Plains; and (3) the cold-tolerant, winter-type varieties grown only in Texas.

Early Maturing Indian Flax Varieties

Commercial varieties of this group are Punjab, Imperial, Punjab 47, New River and other similar strains. Punjab was one of the two varieties introduced for trial plantings in 1938. It was grown for a few years in the Winter Garden and Lower Rio Grande Valley areas but was not well adapted elsewhere because of its very early maturity and susceptibility to low temperatures. A small acreage was grown during the late 1940's in the area just west of Corpus Christi, where it was used for late seeding following a fall crop of vegetables. Only a small acreage of this type is grown at present.

Northern Spring-type Varieties

The commercial varieties of the Northern Great Plains make up most of the Texas acreage. The first variety introduced in 1938 was Bison, but it was damaged by leaf rust and pasmo in 1939, so it was quickly replaced by Rio. Rio was the dominant variety until about 1946. Viking and Norsk became popular for a few years but were replaced about 1948 by B 5128, Bolley's Golden and Crystal. Maritime and Light Mauve were developed by the Texas Station and grown during 1943-46 but now have disappeared from commercial production. By 1948, B 5128 was the most popular variety but by 1953 the acreage had changed largely to the Deoro variety. Small acreages of Linda, Crystal, Redwood, Royal, Minerva and Norland have been grown in some seasons. The Canadian varieties such as Royal and Raja are too early maturing and susceptible to low-temperature injury for fall seeding in Texas. The same is true of the recently distributed varieties Bolley and Arny.

Winter-type Varieties

Flax varieties of this type behave much like winter-type small grains in that in the fall they form a rosette, prostrate growing plant, which remains somewhat dormant and inactive for several months. Because they are not obligate winter in habit, they will produce some seed even from spring seeding, but when spring-seeded they

TABLE 9. PRECIPITATION FOR THE FLAX CROP GROWING SEASON AT BEEVILLE, 1950-59, AND AVERAGE FLAX YIELD IN TEXAS

Year	Precipitation, inches								Average yield of flax, bushels
	October	November	December	January	February	March	April	Total seasonal	
1950	4.94	0	0	1.27	0.19	0.42	2.94	9.76	6.5
1951	0.06	0.13	0	1.71	0.73	2.74	1.09	6.46	3.4
1952	1.64	3.75	0.14	0.54	3.84	1.58	1.76	13.25	8.5
1953	0	3.07	1.02	0.19	1.74	0.39	1.95	8.36	7.0
1954	5.38	0.37	1.92	0.65	0.05	0.36	2.24	10.97	5.3
1955	1.94	1.24	0.33	0.65	1.51	0.55	0.28	6.50	3.0
1956	1.02	1.68	0.46	0.21	0.68	1.54	1.54	7.13	5.5
1957	2.16	0.36	3.38	0.23	1.21	2.61	8.26	18.21	7.0
1958	2.37	4.70	0.45	6.24	6.28	0.77	0.58	21.39	12.0
1959	7.61	0.50	1.62	0.83	5.21	0.05	3.04	18.86	10.5
Long-time average	2.42	2.22	2.38	1.70	1.71	2.23	2.14	14.80	

remain prostrate for a time and are very late maturing. Since low temperatures are important in fall-sown flax production, the advantages of a cold-resistant variety are obvious if the flax-growing area were extended northward.

When commercial flax growing was started in 1938, low temperatures damaged the crop several years. In 1940 temperatures as low as 16° F. at Beeville and 5° F. at Temple destroyed most of the fall-sown flax. Portions of the crop were damaged in 1943, 1948, 1949 and 1952. These losses from low temperatures, combined with the emphasis on production of oil crops during the war years and hopes of extending the flax acreage northward, were the reasons for initiating an active program of developing adapted winter-type varieties by the Texas Station in cooperation with the U. S. Department of Agriculture.

The first winter-type varieties tested were introductions from the Old World. These varieties were Roman Winter from the Netherlands and Turkey from Karacabey, Turkey. A purified composite of several strains was released to Texas growers as Turkey flax in 1947. A private estimate made in 1949 indicated that 10,000 acres of Turkey flax were grown but severe drouth in recent years combined with reduced interest in flax in the southern Blacklands now has eliminated the variety from commercial production.

Breeding work with winter flax consisting of numerous plant selections from Turkey and Roman Winter and from crosses of these varieties to the better adapted spring varieties by the Texas station during 1942-54 culminated in the release of Newturk and later Caldwell. Newturk originated as a pure-line selection from Turkey C. I. 862 and was superior to the parent in hardiness and adaptation. Caldwell was selected from a cross of Roman Winter x Argentina Pale Blue. It was released in 1956 because of its superior yield and greater tolerance to curly top than Newturk. Newturk and Caldwell are rather late maturing and are better adapted to the southern Blacklands than to the main flax-producing area. Seed of Newturk are no longer commercially available. Plant and seed characteristics and disease reaction of adapted Texas flax varieties are given in Table 10.

Yields

Flax is grown in an area of erratic rainfall and even though the 59-year annual average rainfall at Beeville is 29.7 inches, the seasonal distribution may be very poor and ineffective for crop production. When commercial flax production first started, a portion of the acreage was grown on irrigated land in the Winter Garden area (Zavala, Dimmit, Frio and La Salle counties) and in the Lower Rio Grande Valley, but the crop was not sufficiently profitable to persist, so the acreage soon shifted to dryland farming areas. Some flax was grown in the more humid Coastal Plains counties just west of Houston, but high humidity and rainfall during the harvest period soon discouraged production in this area.

Yields of Fall-sown Flax

Yield tests of flax varieties first were made in Texas by the U. S. Department of Agriculture at its U. S. San Antonio Field Station at San An-

TABLE 10. PLANT AND SEED CHARACTERISTICS AND DISEASE REACTION OF SOME FLAX VARIETIES GROWN IN TEXAS

Variety	Flower color	Seed color	Seed size	Relative maturity	Resistance to			
					Wilt	Rust[1]	Pasmo	Curly top
Indian flax varieties								
Punjab	Blue	Brown	Large	Very early	Poor	Poor		Poor
Imperial	Blue	Brown	Large	Very early	Poor	Poor		Poor
Northern Great Plains Varieties								
Arny	Blue	Brown	Medium	Very early	Very good	Excellent	Fair	Good
Arrow	Blue	Brown	Medium	Midlate	Very good	Fair	Fair	Unknown
B 5128	Blue	Brown	Large	Late	Good	Excellent	Fair	Fair
Bison	Blue	Brown	Medium +	Midearly	Very good	Poor	Fair	Unknown
Bolley	Blue	Brown	Medium +	Very early	Good	Excellent	Fair	Poor
Dakota	Blue	Brown	Medium	Midearly	Good	Poor	Fair	Unknown
Linda	Blue	Brown	Very large	Midearly	Very good	Fair	Fair	Fair
Marine	Blue	Brown	Medium	Early	Good	Excellent	Fair	Fair +
Norland	Blue	Brown	Large	Midlate	Good	Good	Poor	Fair +
Raja	Blue	Brown	Large	Early	Fair	Excellent	Fair	Unknown
Redwood	Blue	Brown	Medium +	Midlate	Good	Excellent	Fair	Fair +
Redwing	Blue	Brown	Small	Early	Fair	Fair	Fair	Unknown
Rocket	Blue	Brown	Medium +	Midlate	Fair	Excellent	Poor	Fair
Sheyenne	Blue	Brown	Medium	Early	Very good	Excellent	Fair	Unknown
Victory	White	Brown	Large	Midlate	Good	Good	Poor	Unknown
Golden-seeded varieties								
Deoro	Pink	Yellow	Medium	Late	Fair	Good	Poor	Fair
Viking	Pink	Yellow	Medium	Midlate	Fair	Excellent	Very poor	Very poor
Winter varieties								
Caldwell	Blue	Brown	Medium	Late				Fair +
Newturk	Blue	Brown	Medium	Late				Very poor

[1]Reaction to races of rust now common in the United States.

TABLE 11. COMPARABLE GRAIN YIELD OF FLAX VARIETIES GROWN AT TEXAS STATIONS, 1936-44

Variety	Temple 1941-44		College Station 1936-41		Angleton 1936-42		Victoria 1936-37		Beeville 1935-44		Crystal City[1] 1938-40		Weslaco 1939-44		Ysleta 1943
	No. years tested	Grain yield, bushels	No. years tested	Grain yield, bushels	No. years tested	Grain yield, bushels	No. years tested	Grain yield, bushels	No. years tested	Grain yield, bushels	No. years tested	Grain yield, bushels	No. years tested	Grain yield, bushels	Grain yield, bushels
Abyssinian Yellow			4	5.2	4	6.5	2	5.7	5	13.4	1	26.0	1	21.9	
Argentine 857					2	9.2					1	22.5	2	18.7	
Bison			5	8.6	6	7.8	2	7.3	8	10.9	2	23.8	5	18.1	6.1
Bolley's Golden			5	8.3	5	8.8	2	12.1	7	9.7	2	26.3	3	21.5	
Buda			2	8.1	2	7.9			2	11.6	1	20.2	1	16.4	
Giza			3	11.5	4	7.9			4	12.2	2	29.4	5	21.7	
Light Mauve			1	13.6	2	9.6			3	13.0	1	26.3	4	21.8	
Linota			4	7.5	4	8.7	2	8.1	5	7.7	1	24.3	1	17.6	
N.D.R. 114[2]			4	8.4	3	9.1	2	8.0	4	10.1	1	22.7	1	17.7	
New Golden			1	12.6	2	8.0			3	12.6	1	23.1	2	16.1	
Newland			1	9.9	1	10.4			3	12.9	1	32.2	2	9.2	
Norsk					1	6.3			1	3.5			3	20.0	
Punjab			5	6.4	4	4.3	2	2.7	5	8.5	1	27.5	5	21.2	3.6
Redwing			3	9.5	4	7.6			5	10.9	2	16.8	3	15.9	
Rio	3	5.3	5	10.5	6	9.4			8	12.1	2	23.8	5	19.1	5.7
Turkey Winter[3]	3	10.0	2	12.6	2	8.8	2	7.2	3	9.9	1	10.5	2	16.6	10.0
Viking 981					1	6.8			1	12.6			3	22.1	
Walsh			1	12.6	2	6.9			3	12.9	1	20.1	4	17.8	
Rio x Roman Winter[3]	3	7.1													
Roman Winter	3	7.0													
Roman Winter xA.P.B.[4]	3	8.1													

[1]Irrigated.
[2]North Dakota Resistant 114.
[3]Winter-type flax variety, all others North American commercial varieties.
[4]Argentine Pale Blue.

TABLE 12. COMPARABLE GRAIN YIELDS OF FLAX VARIETIES GROWN IN REPLICATED YIELD TRIALS AT TEXAS STATIONS, 1944-59

Variety	College Station 1944-47		College Station 1948-59		Temple 1945-59		Beeville 1945-59		Kenedy 1948-53		Crystal City 1948-50	
	Number years grown	Grain yield, bushels	Number years grown	Grain yield, bushels	Number years grown	Grain yield, bushels	Number years grown	Grain yield, bushels	Number years grown	Grain yield, bushels	Number years grown	Grain yield, bushels
Arny			2	16.9			2	8.6				
Arrow			2	14.6	2	4.8	3	8.5	4	8.4	3	8.0
B 5128			12	15.9	8	11.0	8	11.0	5	10.1	3	9.2
Bolley			3	15.0			2	8.0				
Bolley's Golden			2	15.1	2	6.9	3	8.8	5	9.6	3	9.0
Caldwell[1]			8	19.1	6	12.7	3	10.9				
Crystal			2	15.8	2	7.4	3	10.0	5	10.6	3	7.1
Dakota			2	14.6	2	6.1	3	9.7	5	9.0	3	7.4
Deoro			12	15.9	8	9.4	8	11.8	5	10.3	3	11.0
Imperial							2	12.2	3	11.6		
Koto					1	6.5	1	5.3	1	6.8	1	10.2
Linda					4	11.6	6	9.4	3	12.1	1	8.0
Marine			2	12.9			3	9.3				
Maritime			1	16.4	1	0.3			1	7.6	2	6.9
Minerva					1	6.5	1	5.1	1	6.2	1	6.6
Newturk[1]	4	14.7	12	11.8	10	10.5	9	8.9	2	9.5	1	4.7
Norland			3	17.9	3	11.6	3	10.7				
Norsk			2	8.3	2	0.3	2	3.0	2	1.5	3	5.3
Punjab 47					1	0.7	3	6.5	2	1.5	1	7.1
Redwood			9	17.9	6	9.7	7	13.0	5	10.4	2	10.2
Rio	4	12.6	12	15.6	1	9.4	9	10.6	5	9.2	3	6.3
Rio x Roman Winter[1]	4	13.1			2	9.0	1	10.8				
Rocket			1	19.8								
Roman Winter[1]	1	12.3										
Roman Winter x A.P.B.[1]	4	13.0			2	8.7	1	10.2				
Royal					1	6.5	1	3.1	1	3.9	1	9.5
Turkey 862[1]	4	13.7	2	11.7	2	10.3	4	8.7	5	7.2	3	5.7
Sheyenne					1	6.5	1	3.5			1	8.1
Victory			2	16.7	2	7.6	3	11.1	5	8.6	3	10.0
Viking			8	13.4	4	11.1	5	11.4			3	11.7

[1]Winter-type flax varieties, all others North American spring-type commercial varieties.

tonio. Most of the commercially important varieties were tested in replicated field plots during 1916-34. A few of the varieties with their average yield were as follows:

N. D. 114	8.9 bushels
Rio	8.8 bushels
Morturos	10.1 bushels
Rosquin	10.6 bushels
Bison	7.7 bushels

These trials suggested that flax might be adapted for fall seeding in Texas so preliminary trials were started by the Texas Station at several South Texas locations in 1934-35 and an enlarged program was initiated in 1936. Comparable yields at several stations during 1936-44 are given in Table 11.

Yield trials during the first few years demonstrated the importance of several production hazards and indicated the types to be grown in the several growing areas. After a favorable season in 1939 when the average yield for the State was 11.5 bushels per acre, the 1940 crop was damaged by a severe freeze and the 1941 crop was damaged by rust and pasmo. It was demonstrated that cold resistance was important at Temple, College Station, Ysleta and Beeville and that early maturing varieties such as Punjab, Giza and Norsk were best adapted to the Winter Garden and Lower Rio Grande Valley. Bolley's Golden, Rio, Light Mauve and New Golden (Deoro) had wide adaptation. Serious losses from flax rust in commercial plantings demonstrated that resistance to this disease was necessary. Rio, Bolley's Golden, Viking and Norsk became the principal commercial varieties during this period.

Comparable yield data for flax variety tests during 1944-59 are given in Table 12. Interest in flax decreased in the southern part of the growing area, so no tests were conducted at Crystal City or Weslaco after 1950. Testing of winter-type experimental strains was emphasized during this period and the winter-type varieties Turkey (1944), Newturk (1948) and Caldwell (1956) were named and distributed. However, severe drouth in the southern Blacklands prevented these varieties from becoming firmly established. These winter-type varieties have some advantage in cold hardiness and are among the highest yielding strains at College Station and Temple.

Tests at Beeville and Kenedy in the main commercial flax areas show that midseason varieties are the most consistent yielding varieties. Redwood, Deoro, Viking and B 5128 have been thoroughly tested throughout the period and have produced the best yields. They also are the principal commercial varieties. The average yield of the winter-type variety Caldwell approaches that of the midseason spring types but Newturk and Turkey have yielded less.

TABLE 13. AVERAGE YIELDS OF SPRING-SOWN FLAX VARIETIES GROWN AT DENTON, 1931-44

Variety	Yield of grain, bushels per acre — Seeded between dates of: March 10-17	March 18-26	March 28-April 13
N.D.R. 114[1]	14.3	11.9	5.8
Linota	12.7	11.7	6.0
Bison	12.4	11.3	5.5
Rio	12.2	9.9	5.3
Morteros	11.2	10.3	4.3
Rosquin	13.1	11.2	5.1
Average	12.7	11.1	5.3

[1]North Dakota Resistant 114.

Yields of Spring-sown Flax

Date of seeding trials of six flax varieties were conducted at the Denton station during 1931-44. All varieties and dates could not be included in each year but results were obtained in eight seasons. A summary of the yield data is given in Table 13.

The highest average yields were obtained when tests were seeded between March 10 to 17, but yields were only 1.6 bushels less when seeded March 18 to 26. Seeding later than March 28 was unfavorable because the crop matured in very hot weather in late June and yields were less than half that of the earlier seedings.

Diseases

Diseases have not been serious factors in Texas flax production except in local areas or in a few seasons. A serious epidemic of rust developed on Punjab flax in the Lower Rio Grande Valley in 1940 and the following year Bison flax was attacked throughout the flax area. Growers were advised to change to Rio, a resistant variety,

Figure 5. Flax plant infected with aster yellows (left), normal plant (right).

Figure 6. Flax plant infected with curly top (left) compared with normal plant (right). Note stunted plants with leaves clasping the stem and profuse branching.

and as resistant varieties have been grown since, no serious damage by rust has occurred. The reaction of some commercial varieties to the more important flax diseases is given in Table 10.

Rust

Flax rust occurs on the leaves and stems as bright-orange pustules or spots about the size of a pinhead. The disease is favored by cool, moist weather. It is spread by tiny microscopic spores which germinate when dew or rain is present, infect the plants and form new pustules about every 10 days. The disease overwinters on flax straw from which the resting spores germinate and infect young flax plants. Portions of stems in uncleaned seed also may serve as a source of initial inoculum. Plowing under of old stubble, crop rotation and growing resistant varieties are practical means of flax rust control.

Pasmo

Pasmo was observed at Crystal City on the first flax crop grown in 1938. It also was reported as severe on experimental plantings at College Station in 1942. It has been reported in fields of South Texas several times but no serious epidemics have occurred. No highly resistant variety is known, although there are some which are classified as tolerant. Pasmo develops primarily on the maturing stem tissues and overwinters on these plant parts. The organism causing pasmo infects young seedlings producing brown, circular lesions on the seed leaves and later yellow-brown spots on the older leaves. The stems do not show infection until near maturity when irregular bands of brown alternating with uninfected green tissue form striking patterns. Infected plants often ripen prematurely and become much darkened by these and other organisms.

Figure 7. Mature flax plants infected with curly top.

Wilt

Flax wilt has been a major disease of flax in the United States and was largely the basis of the popular belief that flax was "hard on the land." Wilt may attack flax at any stage and apparently the causal organism builds up rapidly in any soil so that susceptible varieties grown on the same land may be severely damaged the second year. Use of resistant varieties is the only means of control. The disease may appear as "damped off" seedlings or when older plants are attacked they usually die suddenly because the water and food conducting vessels of the stem are clogged. The lower leaves turn yellow and drop off; then the entire plant dies suddenly. Wilt thrives at temperatures of 70° to 90° F. Since Texas flax is grown during the winter and since most varieties now grown have some degree of resistance, the disease has not been serious in Texas.

Seedling Blights

Several micro-organisms may cause seedling blights, the more important being species of Anthracnose, Rhizoctonia and Fusarium. Usually blights are most severe during periods of cold, damp weather at germination time or soon thereafter. Such conditions also do not favor rapid development of flax seedlings. Seed treatment with a suitable fungicide will reduce this damage under most conditions but will not control it entirely.

Aster Yellows

This disease recently has caused serious losses in flax in the northern Great Plains. Isolated infected plants have been observed in Texas fields and growers should be forewarned of possible increase. Aster yellows is caused by a virus, which is carried to healthy plants by the six-spotted leafhopper. Infected plants are bright yellow, may or may not be stunted and there is considerable distortion of foliage and floral parts. The star-shaped calyxes of the flower are distorted and no seed forms. Damage to the floral parts of the plant is shown in Figure 5.

Curly Top

Curly top also is caused by a virus, which is carried by the sugar beet leafhopper, a related

but different insect from the one which carries the aster yellows virus. Curly top has been an important disease of sugar beets and certain vegetables for many years. During the severe drouth of the early 1950's the sugar beet leafhopper moved eastward from its natural winter habitat in New Mexico, Arizona and West Texas. Outbreaks of curly top were found in flax nurseries at College Station, Temple, Beeville and in many fields in the Beeville - Karnes City area in 1956 and 1957. During the 1958 and 1959 crop seasons when rainfall was above normal in South Texas, no damage occurred and only a few diseased plants were observed. Whether curly top will continue to be an important disease in Texas cannot be predicted.

Curly top infection may be observed from the seedling state to maturity. Infected plants show a characteristic clasping or erectness of leaves about the stem, may be yellow or reddish in color and the lower leaves drop off prematurely. Later, the plants branch abnormally, the upper leaves and flowers are distorted and few seed are formed. The bolls have a pimpling or blistered surface and may be shrunken or greatly reduced in size. Diseased plants are shown in Figures 6 and 7.

During the epidemics in 1956 and 1957 marked varietal differences were observed. The variety Newturk was highly susceptible, whereas Caldwell and some hybrid lines of Rio x Roman Winter were very tolerant. The varieties Redwood, B 5128 and Rio showed moderate tolerance whereas Viking was extremely susceptible. No control measures other than using resistant varieties are practical in Texas because the disease can infect many weeds and the insect vector also may feed on many common weeds. The reactions of several flax varieties to curly top are shown in Figure 8 and Table 14.

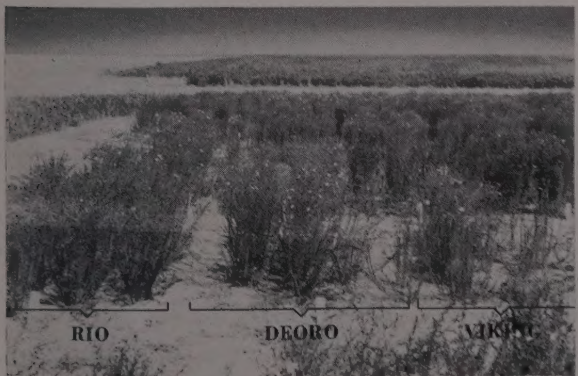

Figure 8. Rio, Deoro and Viking flax showing difference in tolerance to curly top, College Station, 1957.

TABLE 14. REACTION OF A SELECTED GROUP OF FLAX VARIETIES TO CURLY TOP AT TEXAS STATIONS

	Percent infected plants				
	College Station			Temple	
Variety	1955	1956	1957	1956	Average
Newturk	20	50	73	73	54.0
Viking	18	30	70	63	45.1
Deoro	15	16	50	43	31.0
Rio	23	10	38	53	30.9
Linda	20	9	53	38	30.0
B 5128	24	6	33	43	26.5
Redwood	18	6	43	35	25.4
Caldwell	7	7	33	48	23.6
Norland		8		25	
Marine		5		38	
Rocket		11		43	

Insects

Insects have not been a serious problem in flax production in Texas. Cotton bollworms have damaged a few fields in certain areas. Leaf hoppers, which may carry aster yellows or curly top virus, are a potential source of damage to the crop, but control measures are not practical under most conditions.

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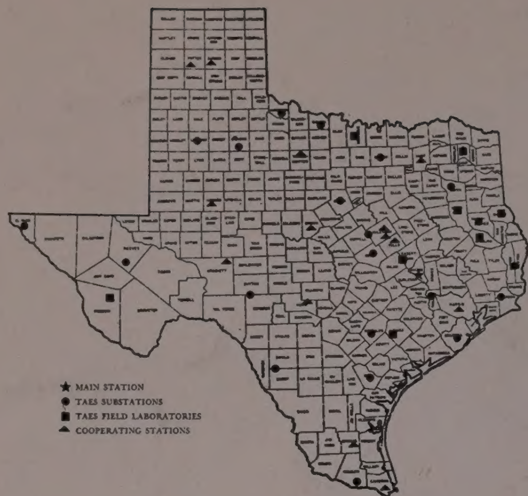

Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

★

The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of ten parts of the Texas A&M College System

ORGANIZATION

IN THE MAIN STATION, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

OPERATION

THE TEXAS STATION is conducting about 400 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

Conservation and improvement of soil	Beef cattle
Conservation and use of water	Dairy cattle
Grasses and legumes	Sheep and goats
Grain crops	Swine
Cotton and other fiber crops	Chickens and turkeys
Vegetable crops	Animal diseases and parasites
Citrus and other subtropical fruits	Fish and game
Fruits and nuts	Farm and ranch engineering
Oil seed crops	Farm and ranch business
Ornamental plants	Marketing agricultural products
Brush and weeds	Rural home economics
Insects	Rural agricultural economics

Plant diseases

Two additional programs are maintenance and upkeep, and central services.

Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service

AGRICULTURAL RESEARCH seeks the WHATS, the WHYS, the WHENS, the WHERES and the HOWS of hundreds of problems which confront operators of farms and ranches, and the many industries depending on or serving agriculture. Workers of the Main Station and the field units of the Texas Agricultural Experiment Station seek diligently to find solutions to these problems.

Today's Research Is Tommorrow's Progress